Investigation into Interspecific Encounters of the Sea Hare *Aplysia dactylomela* Rang, 1828

(Gastropoda : Opisthobranchia)

BY

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(1 Text figure)

INTRODUCTION

Sea hares of the genus *Aplysia* (Gastropoda: Opisthobranchia) have become the targets of intense investigations by neurophysiologists (see Kandel, 1979 for review), yet, until recently, little has been known concerning the behavioral ecology of these molluscs. Field studies that have been done in the United States have been performed predominantly on *Aplysia californica* Cooper, 1863 (Winkler, 1959; Winkler & Tilton, 1962; Kupferman & Carew, 1974; Audeskirk, 1979).

Studies on *Aplysia dactylomela* Rang, 1828 have been much more limited. Tobach *et al.* (1965) examined inking in *A. dactylomela;* and Lederhendler *et al.* (1975) and Tobach (1978) looked at aggregation and ecological adaptations of *A. dactylomela* in the Bahamas. More recently, DiMatteo (1980a, b) has looked into inking, and its role as a defensive mechanism in *A. dactylomela* from Florida waters.

Information is at a minimum concerning the life history of this animal, especially where interspecific encounters are concerned. While *Aplysia dactylomela* appears to lead an adult life free of most predation, there are reports of predators feeding on *A. dactylomela* (see DiMatteo, 1980a for review). Any type of quantitative examination in this area is however, woefully lacking. The data presented here are the results of a study designed to investigate more accurately the behavioral ecology, and the strategies employed by these soft-bodied molluscs in avoiding predation.

The experiments were set up to determine if *Aplysia dactylomela* would respond in a defensive way to the presence of carnivorous prosobranch gastropods, and echinoderms known to cause withdrawal responses in other gastropods. Since Lederhendler *et al.* (1975) found an avoidance to the cnidarian *Cassiopea xamachana* Bigelow, from sea hares in the Bahamas, this was also checked to see if this population of sea hares reacted in a similar manner.

METHODS and MATERIALS

The study was performed at Pigeon Key, and Bahia Honda State Park, of the lower Florida Keys, U.S.A. Sea hares were collected from shallow water grass flats which border most of this area. Sea hares were maintained in recirculating salt water tanks. All sea hares were tested within one day of collection.

In the first experiment, sea hares were exposed to one of 5 different test animals. These test animals were (1) the predatory gastropod *Fasciolaria tulipa* (Linnaeus, 1758) (sizes ranged from 5.1 - 10.5 cm); (2) the asteroid *Echinaster sentus* (Say); (3) the holothuroidean *Astichopus multifidus* (Sluiter); (4) the herbivorous gastropod *Strombus gigas* (Linnaeus, 1758); and (5) empty *Fasciolaria* shells. Groups 4 and 5 were used as controls. The empty *Fasciolaria* shells were prepared by removing the animal or obtaining already empty shells. Shells were then boiled, soaked and rinsed in alcohol, and dried. The sizes of the shells were similar to the living *Fasciolaria* used.

Each sea hare was placed in an aquarium, and one of the five test animals was introduced. More than one test animal would be introduced to ensure that the sea hare would make contact. The order of presentation of the test animals was randomized throughout the experiments.

Results from the above trials were analyzed using the χ^2 test with $p < 0.05$. Each category was arranged in the order of the number of withdrawals shown by the sea hares, and compared to the next. The categories were also lumped within each group and tested as well.

Trials with *Cassiopea* were performed in the same manner as discussed above, and four treatments were tested: (1) live *Cassiopea*; (2) *Cassiopea*, previously ground and placed on a glass rod; (3) *Cassiopea*, previously ground, to which 10% acetic acid was added to act as a stimulus for discharge of nematocysts, placed on glass rod; and (4) glass rod, no *Cassiopea* (control). In 2 and 3 above, *Cassiopea* were ground in a bowl with a pestle. The consistency of the mixture was such that it would cling to the glass rod. This would then be placed in front of a moving sea hare, or gently touched to the anterior of the sea hare. Data from this set of trials were also examined by χ^2, with $p < 0.05$.

RESULTS

Results from the first set of trials are shown in Table 1. Figure 1 shows the categories set up as 3 groups, each group being significantly different from the other two in the number of withdrawals. Categories within each group are not significantly different from each other.

The control group consisted of the empty *Fasciolaria* shells, and the living *Strombus*. The number of withdrawals by the sea hares for this group was significantly lower than those of the other two groups, when tested separately, and when lumped together and tested.

The *Fasciolaria* categories are designated as group I. This group differed significantly from the control group ($\chi^2 = 6.66$), and from group II ($\chi^2 = 13.75$). While the two *Fasciolaria* categories were run at different times with

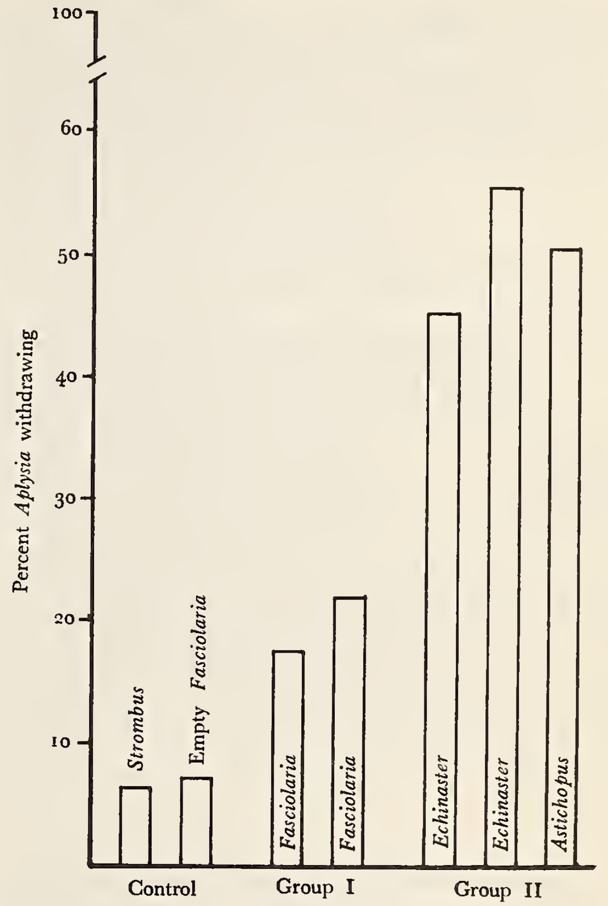

Figure 1

Withdrawal rates by *Aplysia* to the various test animals, arranged into three significantly different groups

Table 1

Results showing the number of withdrawals by *Aplysia dactylomela* when encountering the various test animals used in the trials

Response of *Aplysia*	Source of stimulus						
	Strombus	Empty *Fasciolaria*[1]	*Fasciolaria*		*Echinaster*		*Astichopus*
Date:	4/79	7/80	4/79	7/80	4/79	7/80	7/80
Number of trials	50	85	50	85	50	55	70
Number of *Aplysia* withdrawing	3	6	11	15	28	25	36
Percent of *Aplysia*	6.0	7.1	22.0	17.6	56.0	45.5	51.4

4/79—Number of sea hares tested = 10; 7/80—Number of sea hares tested = 16
[1]refers to cleaned shell, no animal (see text for preparation)

different animals (see Table 1), no significant difference existed between them.

Group II consisted of the echinoderms *Echinaster* and *Astichopus*. These test items all received high numbers of withdrawals by the sea hares. The difference between the two *Echinaster* categories is not significant ($\chi^2 = 0.98$).

Table 2

Results showing the number of withdrawals by *Aplysia dactylomela* when encountering *Cassiopea*

Response of *Aplysia*	Source of stimulus[2]			
	Control	A	B	C
Number of trials	92	81	76	75
Number of *Aplysia* withdrawing	11	62	66	24
Percent of *Aplysia*	11.9	76.5	86.8	32.0
	$X^2 = 55.32$, df = 3, p 0.05			

Number of sea hares tested = 15

[2]Control—glass rod; A—glass rod/*Cassiopea;* B—*Cassiopea;* C—glass rod/*Cassiopea*/acetic acid.

Table 2 shows the results from the *Cassiopea* trials. The sea hares did withdraw significantly higher with contact by *Cassiopea*. No difference was observed between the sea hares' response to the live *Cassiopea* and the glass rod *Cassiopea* mixture ($\chi^2 = 0.12$). The number of withdrawals from the glass rod/*Cassiopea* mixture, and the glass rod/ *Cassiopea* acetic acid mixture, were significantly different with $\chi^2 = 16.79$.

DISCUSSION

Results from the first set of trials (Figure 1) provide the first experimental evidence indicating an escape response by *Aplysia dactylomela* towards predatory gastropods. Previous work (KANDEL, 1979) has shown an escape response by *A. californica* upon contact with the asteroid *Astrometis sertulifera*, with the stimulus appearing to be mechanical rather than chemical. The response shown by *A. dactylomela* in this study was similar to that described for *A. californica*. The stimulus here was also mechanical, and this author agrees with KANDEL (1979) that the withdrawal seems to be caused by the pinching action of the pedicellaria of the starfish. The response of the sea hare to the sea star was virtually identical to that described by HENING *et al.* (1976); *i.e.*, a quickened crawling, with rapid pedal waves, much quicker than for routine crawling. The case for this mechanical stimulus was strengthened by exposing the sea hares to the holothuroidean *Astichopus multifidus*. The sea hares' responses were similar to those described for their reaction toward the asteroid. While *Astichopus* does not possess pedicellaria it is extremely warty and covered with protuberances considered to be sensory. The sea hares appeared to be undaunted by the presence of *Astichopus* until contact was made, then withdrawal was observed. *Astichopus* is a strict deposit feeder, thus it would not be of any advantage of the sea hare to show an escape response due to chemical signals from this animal. While *Echinaster* is omnivorous, it probably does not pose much of a threat to adult *Aplysia*. Thus, this mechanical stimulus may be more than adequate to deter sea hares. It should be interesting to examine the responses of *A. dactylomela* to some of the more voracious predatory sea stars, and chemicals emitted by them.

Fasciolaria tulipa is molluscivorous, and a very voracious predator in the Florida Keys. While the sea hares would often make contact with *Fasciolaria,* the exact stimulus eliciting the escape response is unclear. Given the importance of chemicals as mediators of molluscan escape responses (see MACKIE & GRANT, 1974 for review), it would seem likely that chemicals play some role in this case as well.

The results from the *Cassiopea* trials concur with those of LEDERHENDLER *et al.* (1975) for *Aplysia* in the Bahamas. In this study, sea hares reacted to contact with *Cassiopea* by rapidly withdrawing and turning away. The stimulus appeared always to be tactile, and as the trials with the acetic acid indicates, was most likely caused by the nematocysts present on the *Cassiopea*. Similar withdrawal responses have also been observed in *A. dactylomela* to contact with the gastropod *Cymphoma gibbosum* (DiMatteo, unpublished data), a species feeding exclusively on gorgonians bearing nematocysts. The response of the sea hare was always the same rapid retraction of the anterior end, with the sea hare turning or moving in a wide arc around the *Cassiopea*. This response was highly stereotyped for all sea hares tested.

This study quantifies and substantiates impressions given from casual observations in past literature. It should come as no surprise that *Aplysia dactylomela* shows some of the escape responses so common in opisthobranchs. *Aplysia dactylomela* is endowed with many mechanisms making it unpalatable to many predators, and together with the escape responses discussed in this paper, allow it to avoid much predation in the Florida Keys as adults.

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